HOLOCENE VEGETATION RECORDS FROM THE MARBLE MOUNTAINS, SOUTHERN MOJAVE DESERT, CALIFORNIA

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for

Bureau of Land Management
Desert Planning Staff
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Holocene Vegetation Records From The Marble Mountains, Southern Mojave Desert, California

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Ancient packrat middens have been found at three localities in the Marble Mountains of San Bernadino County, California. All occur in the southern Mojave brittle bush - creosote bush communities of dry, rocky slopes. The localities range from 475 m. (1560 ft.) to 890 m. (2920 ft.) elevation (Table 1).

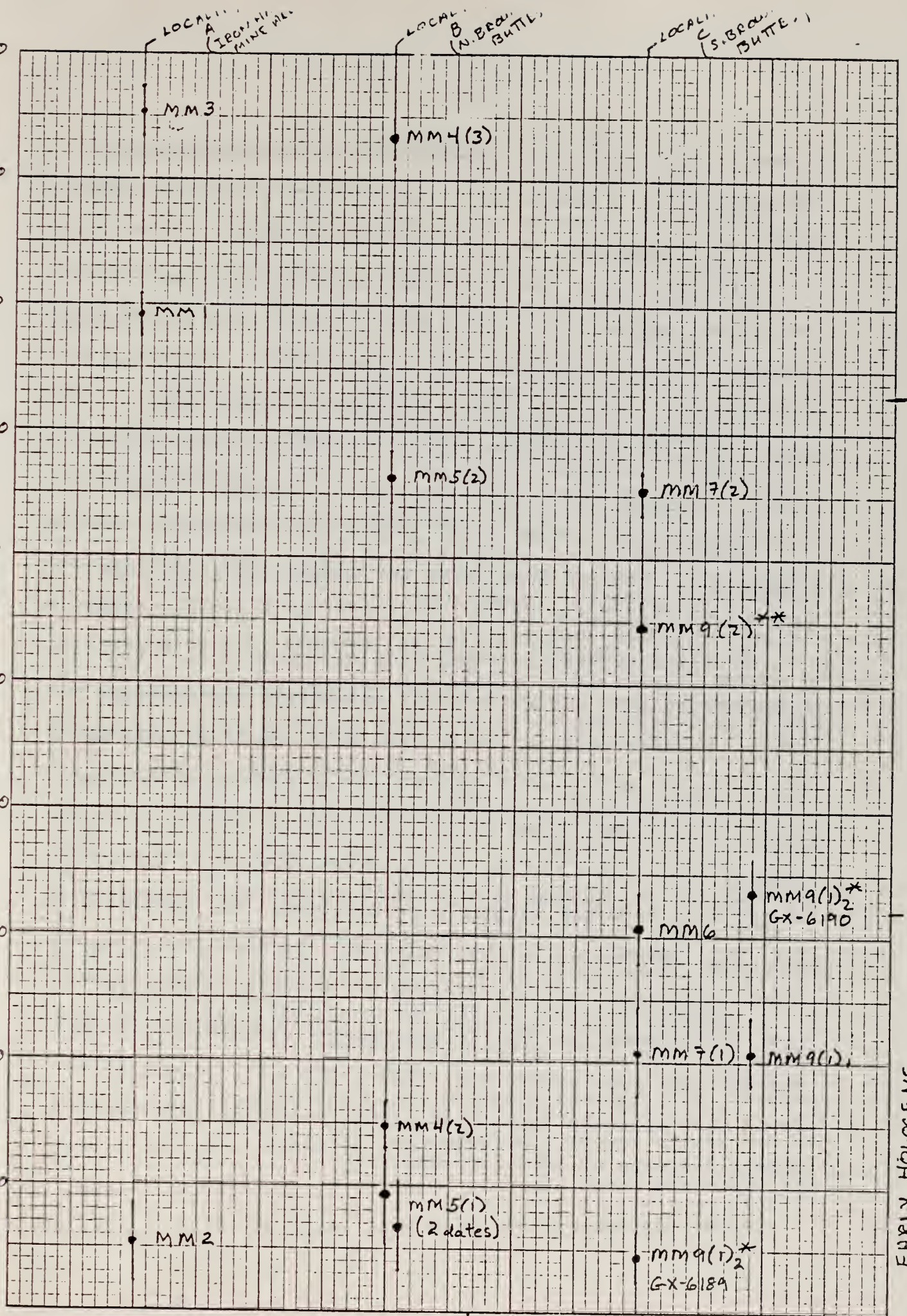
The distribution of radiocarbon ages on the Marble Mountains packrat middens is ideal for the study of the presettlement vegetation of the Mojave Desert. Seven of the thirteen macrofossil assemblages are of early Holocene age, between ca. 11,000 B.P. and ca. 7800 B.P. (radiocarbon years before present; Figure 1, Table 1). Packrat midden and fossil pollen data from throughout the Southwest show rapid change in plant communities starting at about 11,000 B.P. (Van Devender and Spaulding 1979; Martin and Mehringer 1965; Mehringer 1967). However, the present desert communities were not fully developed until ca. 7800 B.P. and perhaps later in some areas (Van Devender 1977; Phillips 1976). The early Holocene was a time of flux with changing climatic regimes and plant species distributions. The fossil record from this period is of the development of deserts as we know them now.

Age Determination. I prefer to date a single extralocal plant taxon from a fossil packrat midden whenever possible. However, when dealing with desert assemblages it is often impossible to collect enough mass of a single taxon to radiocarbon date. Hence, most of the dates from the Marble Mountains middens are on undifferentiated twigs or packrat fecal pellets.

Table 1. Packrat midden sites and radiocarbon ages from the Marble Mountains, southern Mojave Desert, San Bernadino County, California.

Marble Mountains 9(1)$_1$	2820 ft.	SW-facing andesite talus slopes	8905 ± 265 B.P. GX-6188	*Juniperus* sp. Twigs & seeds
" "9(1)$_3$	"	"	10,555 ± 210 B.P. GX-6189	Misc. Twigs
"	"	"	7635 ± 260 B.P. GX-6190	*Neotoma* feces
" "9(2)	"	"	5520 ± 190 B.P. GX-6191	*Neotoma* feces

Figure 1. Radiocarbon age determinations on packrat midden samples from the Marble Mountains. Ages are presented as a mean (dot) and one standard deviation (verticle line) from the mean. There is no horizontal scale. MM, Marble Mountains.



** Probably a contaminated sample * Contaminated sample

AGE DISTRIBUTION OF PLANT MACROFOSSIL ASSEMBLAGES FROM

A date of 1465 ± 85 B.P. (GX-6179) is on creosote bush from the Marble Mts. 3 midden and a date of 8905 ± 265 B.P. (GX-6188) is on Juniperus sp. from Marble Mts. $9(1)_1$.

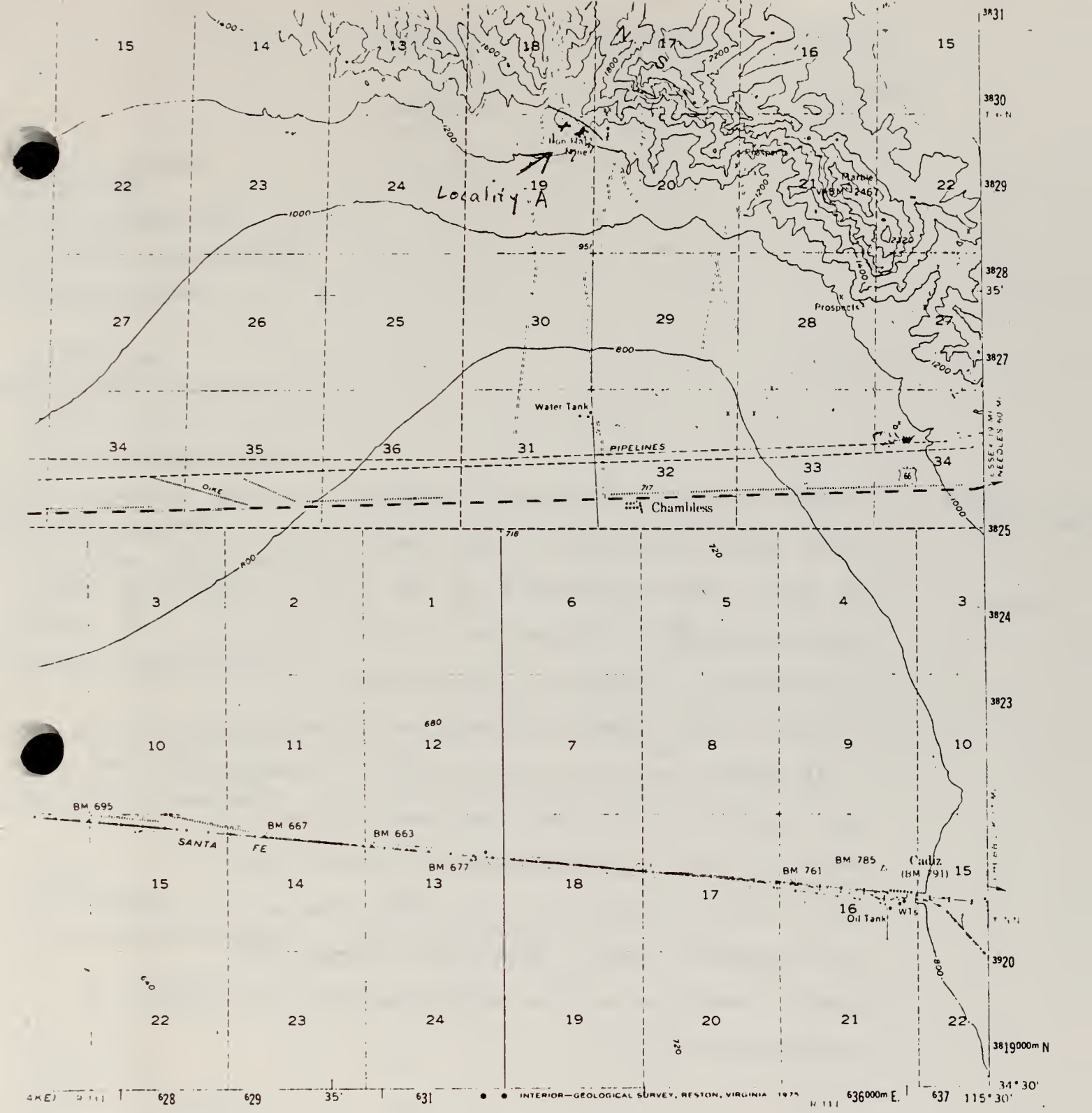
Multiple dating was performed to verify the ages of two midden samples that have a high diversity and would figure strongly in paleoecological reconstructions. A sample of miscellaneous twigs and Prunus fasciculata seeds from Marble Mts. 5(1) yielded an age of 10,090 ± 380 B.P. (GX-6182) and Neotoma feces from the same assemblage yielded a contemporaneous age of 10,325 ± 350 B.P. (GX-6183). A single age, averaged from these two values (Long and Rippeteau 1974) is 10,210 ± 260 B.P.

A second replicate dating test on Marble Mts. $9(1)_2$ demonstrated that the macrofossil assemblage was contaminated. Undifferentiated twigs from this sample yielded an age of 10,550 ± 210 B.P. (GX-6189) while associated packrat fecal pellets were dated at 7635 ± 260 B.P. (GX-6190). The species list from MM $9(1)_2$ is presented (Table 4), but it is excluded from any further consideration. The Marble Mts. 9(2) assemblage is also rejected. It contains extra-local mesophytes (such as Ephedra cf. viridis, Artemisia sec. Tridentatae, and Salvia mohavensis) associated with a mid-Holocene radiocarbon age (5520 ± 190 B.P., GX-6191). It is most unlikely that these plants persisted into the middle Holocene at this locality.

The Southern Marble Mountains. Locality A is the Iron Hat Mine area in the southern Marble Mountains, north of Chambless and consists of three sites on xeric south and southeast facing limestone slopes (Fig. 2). Marble Mts. 1 and 3 are of late Holocene age, with radiocarbon dates of 3080 ± 165 B.P. (GX-6177) and 1465 ± 180 B.P. (GX-6179; Table 1), respectively. These two macrofossil assemblages are dominated by Larrea tridentata and Encelia farinosa, the most important plants in the modern community (Table 2). Neither sample suggests appreciable change in the local plant communities except, perhaps, a decrease in the importance of Bebbia juncea in the last 1400 years. Sorensen's indices of similarity (IS; computed as 2c/A+B x 100; Mueller-Dombois and Ellenberg 1974) between perennials in the fossil assemblages and those occuring within 50 m. of the site (the relevé) are relatively high (Table 2; Fig. 3a).

Marble mts. 2, the third assemblage from Locality A, is radiocarbon dated at 10,465 ± 330 B.P. (GX-6178). It contains a desertscrub assemblage domunated by Ephedra sp. and Lycium sp. (perhaps Lycium californicum; Table 2). It lacks both creosote bush and brittle bush as well as any woodland plants, with the possible exception of Opuntia cf. polyacantha. Records of similar age at low elevations throughout the Southwest contain juniper and other woodland species. The Marble mts. 2 record is dominated by extralocal desert shrubs but is singular in its lack of woodland plants. Xeric exposure, low elevation, and limestone substrate may account for their

Figure 2. Locality A in the southern Marble Mountains. A dolomitic limestone outlier is separated by a massive thrust fault (black line) from the main igneous complex of the Marble Mountains. A isolated population of Salvia cf. funerea occurs on these calcareous rocks.



5000

2 3 4 MILES

12000 15000 18000 21000 FEET

3 4 5 KILOMETRES

40 FEET

AL DATUM OF 1929

ROAD CLASSIFICATION

Medium duty — — — Light duty ——

Unimproved dirt . . .

U S Route

CALIF

QUADRANGLE LOCATION

MAP ACCURACY STANDARDS

ORADO 80225 OR RESTON, VIRGINIA 22092

SYMBOLS IS AVAILABLE ON REQUEST

CADIZ, CALIF.

N3430—W11530/15

1956

AMS 2853 II—SERIES V795

wgt

= Field

Table 2. Plants from Marble Mountains Locality A. Modern plant species recorded in the relevé (r) are to the left, fossil occurences (m) are to the right. Relative abundance classes are: 5, very abundant; 4, abundant; 3, common; 2, occassional; 1, rare; Q, one or two fragments, a possible contaminant; x, an annual occuring in the relevé; 0, a perennial occuring in the area, but greater than 50 m. from the site. N, total number of species; N_p, total number of perennials (excluding grasses); IS, Sorensen's index of similarity between the fossil assemblage and the relevé from that site (calculated with N_p).

	3080±165 GX-6177 Marble Mts. #1		1046±330 GX-6178 Marble Mts #2		1465±180 GX-6179 Marble Mts #3		
	r	m	r	m	r	m	
[redacted]rossia dumosa	—	—	—	1			
Argemone sp.	1	—	1	—	1	-	
Aristida adscensionis	x	—	x	—	x	—	
Atrichoseris platyphylla	0	1	0	1	0	1	Check these
Bebbia juncea							
B. Canissonia	x	1	x	—	x	-	
Chorizanthe brevicornu	—	—	—	1	x	-	
C. rigida cf.	—	—	x	—	x	-	
Cryptantha angustifolia	x	—	x	—	x	-	
Dalea spinosa	0	—	0	—	0	-	
Ditaxis lanceolata	2	—	1	—	1	-	Not present
Echinocereus polyacanthus	1	—	0	1	1	—	
Encelia farinosa	3	5	3	—	1	3	
Ephedra sp.	—	—	—	4	—	—	California
Eriogonum hoffmannii	—	—	—	1	—	—	
E. fasciculatum of trichopes	x	—	x	—	x	—	
Eucnide rupestris	1	—	2	—	1	-	
Ferocactus acanthodes	2	2	1	1	1	1	
Gilia sp.	x	1	x	—	x	-	
Gryptis emoryi	0	—	1	—	1	-	Not present
Haplopappus setosissimus	x	—	x	—	x	-	
Hymenoclea tridentata	2	3	2	—	3	5	
Hymenoxys sp.	—	—	—	3	—	—	
Hyptis sp.	x	—	x	—	x	-	
Oligomeris linifolia	x	—	x	—	x	-	
Opuntia basilaris	1	2			1	2	
O. echinocarpa	0	—	0	—	0	—	
O. polyacantha	—	—	—	1	—	—	
Peucephyllum schottii	0	1	0	—	0	—	
Perityle emoryi	1	1	1	—	1	1	
Phacelia cf. cumulata	x	—	x	—	x	-	
P. [redacted]lia sp.		2	—	1	—	—	
P. [redacted]is crassifolia	1	3	1	2	1	2	
Plantago insularis	x	—	x	—	x	-	
Porrocaroxis pleuresteta	—	1	1	—	1	1	

	3080±165 GX-6177 Marble Mts #1		10,465±330 GX-6178 Marble Mts #2		1465±180 GX-6179 Marble Mts #3		
	r	m	r	m	r	m	
cf. *Salvia funerea*	1	3	1	1	1	–	
S. mohavensis	–	–	–	1	–	–	
Sphaeralcea sp.	1	1	1	2	–	–	
Tidestromia oblongifolia	1	–	1	–	1	–	unburned present
N	23	14	24	14	25	8	
Np	11	10	11	11	12	8	
IS $\left(\frac{Zc}{A+B}100\right)$	/	76.2	/	36.4	/	70.0	

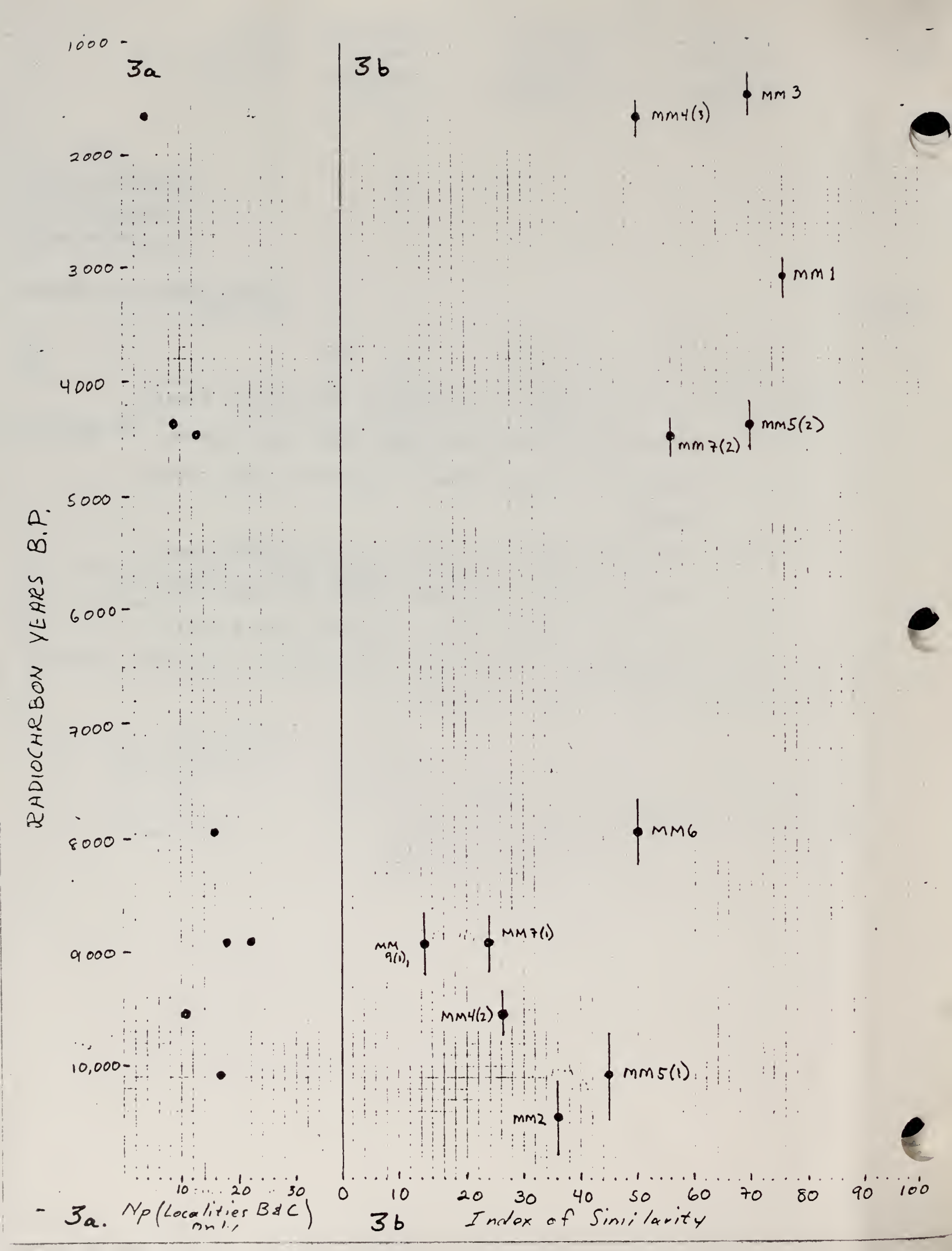
N = all taxa within 50 m of the midden site
Np = " perennials " " " " "

Relative abundance classes (Applied to perennials in the relevé and macrofossils in the midden assemblages)

5 - Very abundant
4 - Abundant
3 - Common
2 - Occasional
1 - Rare
x - An annual species occurring in the relevé
O - A perennial occurring on the upper bajada, greater than 50 m distant and off the ~~modern~~ bedrock slopes.

Figure 3a. The total number of perennials (N_p) in the fossil assemblages from Localities B and C are plotted against the mean of the ^{14}C ages for those assemblages.

3b. Sorensen's index of similarity (IS) between each fossil assemblage and the relevé from that site is plotted against the radiocarbon age of that assemblage.


3a
3b
1000
2000
3000
4000
5000
6000
7000
8000
9000
10,000
RADIOCHRBON YEARS B.P.
MM 3
MM4(3)
MM 1
MM5(2)
MM7(2)
MM6
MM 9(1),
MM7(1)
MM4(2)
MM5(1)
MM2
10
20
30
0
10
20
30
40
50
60
70
80
90
100
3a. Np (Localities B & C mm1)
3b Index of Similarity

absence as well as the site's westerly geographic location, in the intense Mojavean rainshadow.

Salvia cf. funerea is common on the limestone slopes of Locality A, nearly 130 km. (80 mi.) southeast of its main range in the Death Valley region. It is restricted to limestone in the Iron Hat Mine area; an island of calcareous substrate in a sea of igneous rock. Its presence in the Marble Mts. 2 assemblage implies that, while Larrea tridentata and Encelia farinosa are post-Wisconsinan invaders to this locality, Death Valley sage may have been present here, perhaps as an isolated population, for considerably longer.

The Northern Marble Mountains. Ancient middens were recovered from two localities in the northern Marble Mountains. Locality B, east of the Brown Buttes, contains the Marble Mts. 4 and 5 sites at 890 m. (2920 ft.) elevation (Fig. 4). The shelters occur in rhyolitic breccia at the head of west and southwest facing talus slopes, ca. 30 m. above the alluvial fan. Nearby cliffs provide partial shade for what would otherwise be a very xeric locality. The desertscrub community in the vicinity is dominated by large numbers of apparently young Encelia farinosa plants with occassional Larrea tridentata, Ambrosia dumosa and Bebbia juncea (Table 3). Feral burro (Equus asinus) trails, bedding areas, and dung piles are common near the head of the talus slopes, in the shade of the cliffs.

Figure 4. Localities B and C in the northern Marble Mountains. The Marble Mts. 4 and 5 sites (Locality B) occur at the base of bedrock outcrops that form the walls of a small rincon. The Marble Mts. 6, 7, and 9 sites (Locality C) occur within 12 m. (40 ft.) of the ridge crest, at the top of steep, south facing talus slopes.

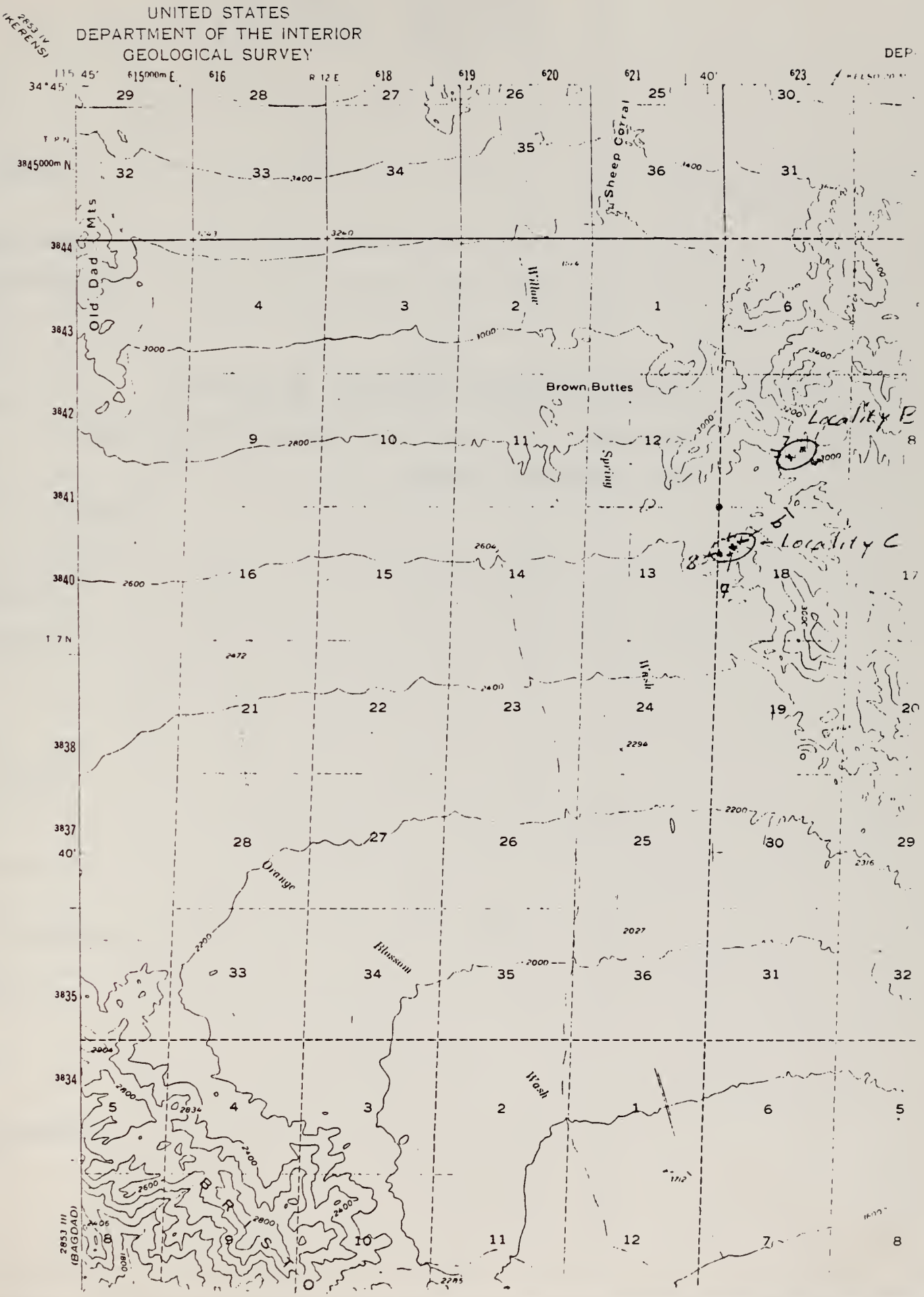

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Old Dad Mts
Sheep Corral
Brown Buttes
Locality B
Locality C
Orange
Wash
Wash
Wash
Wash
Spring
2853 IV (KERENS)
2853 III (BAGDAD)

Table 3. Plants from Marble Mountains Locality B.
See Table 2 for a key to abbreviations and relative abundance values.

	Marble Mts. 4				Marble Mts. 5	
	Current Vegetation	4(2) 9515± 185 BP GX-6160	4(3) GX-6151 1680± 150	Current Vegetation	5(1) 10,090± 380 GX-6182 10,325± 350 GX-6183	5(2) 4360± 210 GX-6184
Acacia greggii	0	1	–	0	–	–
Amaranthus sp.	1	–	–	–	1	–
Ambrosia dumosa	2	–	–	1	–	2
Amsinckia tesselata	x	1	–	x	1	–
Aristida adscensionis	x	–	–	x	–	–
Aristida sp.	–	–	1	–	1	1
Asclepias sp.	–	–	–	–	1	–
Astragalus sp.	–	1	1	–	2	–
Bebbia juncea	2	–	2	1	1	2
Brickellia sp.	0	3	–	1	2	1
Cheirenthe cf. brevicornu	–	1	–	–	1	1
Cheirenthe cf. rigida	–	–	–	–	–	1
Haplopappus laricifolius	–	–	–	–	3	–
[redacted] ramosissima	–	–	–	–	2	–
Cuscuta mexicana	–	–	–	–	1	–
Cryptantha sp.	x	–	–	x	–	–
Cucurbita sp.	–	–	–	–	–	1
Datexis lanceolata	1	–	–	1	–	–
Echinocereus sp.	–	2	–	–	1	–
Encelia farinosa	5	3	3	5	–	4
Encelia sp.	–	–	–	–	(1)	–
Eriogonum cf. fasciculatum	1	–	–	1	2	(1)
E. heermannii	–	1	–	–	–	–
E. inflatum	x	–	–	x	–	–
E. trichopes	x	–	–	x	–	–
Ferocactus acanthodes	1	–	–	1	–	2
Festuca sp.	–	–	–	–	1	–
[redacted] sp.	x	–	–	x	–	–
Haplopappus cuneatus	–	–	–	–	2	–

	Marble Mts 4			Marble Mts 5		
	current vegetation	4(2)	4(3)	current vegetation	5(1)	5(2)
cf. Haplopappus linearifolius	–	1	–	–	2	–
Hilaria rigida	0	–	–	1	–	–
Hilaria sp.	–	–	–	–	–	1
Hyptis emoryi	1	–	–	2	–	–
Langloisia sp.	–	–	–	–	1	–
Larrea tridentata	2	(1)	4	2	–	3
Lepidium sp.	x	1	–	x	1	–
cf Lycium californicum	0	–	–	2	–	–
Mirabilis sp.	–	–	–	–	3	–
Oenothera sp.	–	2	–	–	–	–
Opuntia basilaris	1	–	–	2	2	–
O. echinocarpa	0	–	–	0	–	–
O. ramosissima	0	–	–	0	–	–
Pectocarya sp.	–	1	–	–	1	1
Phacelia cf. crenulata	x	–	–	x	–	–
Physalis crassifolia	1	1	1	2	1	2
Plantago insularis	x	–	–	x	–	–
Plantago sp.	–	1	1	–	2	–
Pleurocoronis plurisetosa	1	–	–	1	–	–
Prunus fasciculata	–	–	–	–	2	–
Salvia sp.	–	–	–	–	1	–
Salvia michaelis	–	1	–	–	4	–
Sphaeralcea sp.	1	–	–	1	–	–
Thysanocarpus sp.	–	1	–	–	1	–
Yucca schidigera	0	2	–	0	3	–
N	21	18	7	24	29	14
Np	12	11	4	14	17	9
IS	–	26.1	50.0	–	45.2	69.6

(15 min)

Locality C, about 1.3 km. southwest of Locality B, at 870 m. (2840 ft.) elevation, is a rich source area for fossil middens. The Marble Mts. 6, 7, and 9 sites occur at the head of steep, south facing talus slopes, ca. 90 m. above the alluvial fan (Fig. 4). The substrate is rhyolitic breccia with Encelia farinosa as the dominant, while Larrea tridentata, Ambrosia dumosa, and Peucephyllum schottii are locally important. The Locality B and C habitats are similar and, although the latter is slighly more xeric, their fossil records are treated together.

The paleoecological record from the northern Marble Mountains sites is one of early Holocene mixed desertscrub assemblages giving way to Encelia farinosa and Larrea tridentata by ca. 7900 B.P. (Fig. 5). Salvia mohavensis, Brickellia sp., cf. Haplopappus laricifolius, H. cuneatus, and Yucca schidigera are the most common extralocal taxa in four midden samples dating from ca. 10,200 B.P. to ca. 8900 B.P. (Fig. 5; Table 4). Other extralocal desertscrub species, such as Coleogyne ramosissima, Ephedra sp., Opuntia cf. acanthocarpa, and cf. Dalea fremontii occur in smaller amounts (Table 3, 4). Juniper occurs in Marble Mts. 7(1) and Marble Mts. $9(1)_1$, contemporaneous samples at ca. 9000 B.P., but not in two older samples, MM 4(2) and MM 5(1), dated at ca. 9500 B.P. and ca. 10,200 B.P., respectively. Yucca whipplei and Artemisia sec. Tridentatae also occur only in MM 7(1) and MM $9(1)_1$, while Y. brevifolia occurs in MM $9(1)_1$.

Figure 5. The relative abundance of important plants species in macrofossil assemblages from Localities B and C plotted against the mean of their radiocarbon age. The key to abundance ratings is given in Table 1, except for the dot which signifies one or two fragments, a possible contaminant. Included are all perennials (excluding grasses) that are rated as common (3) or above in at least one sample.

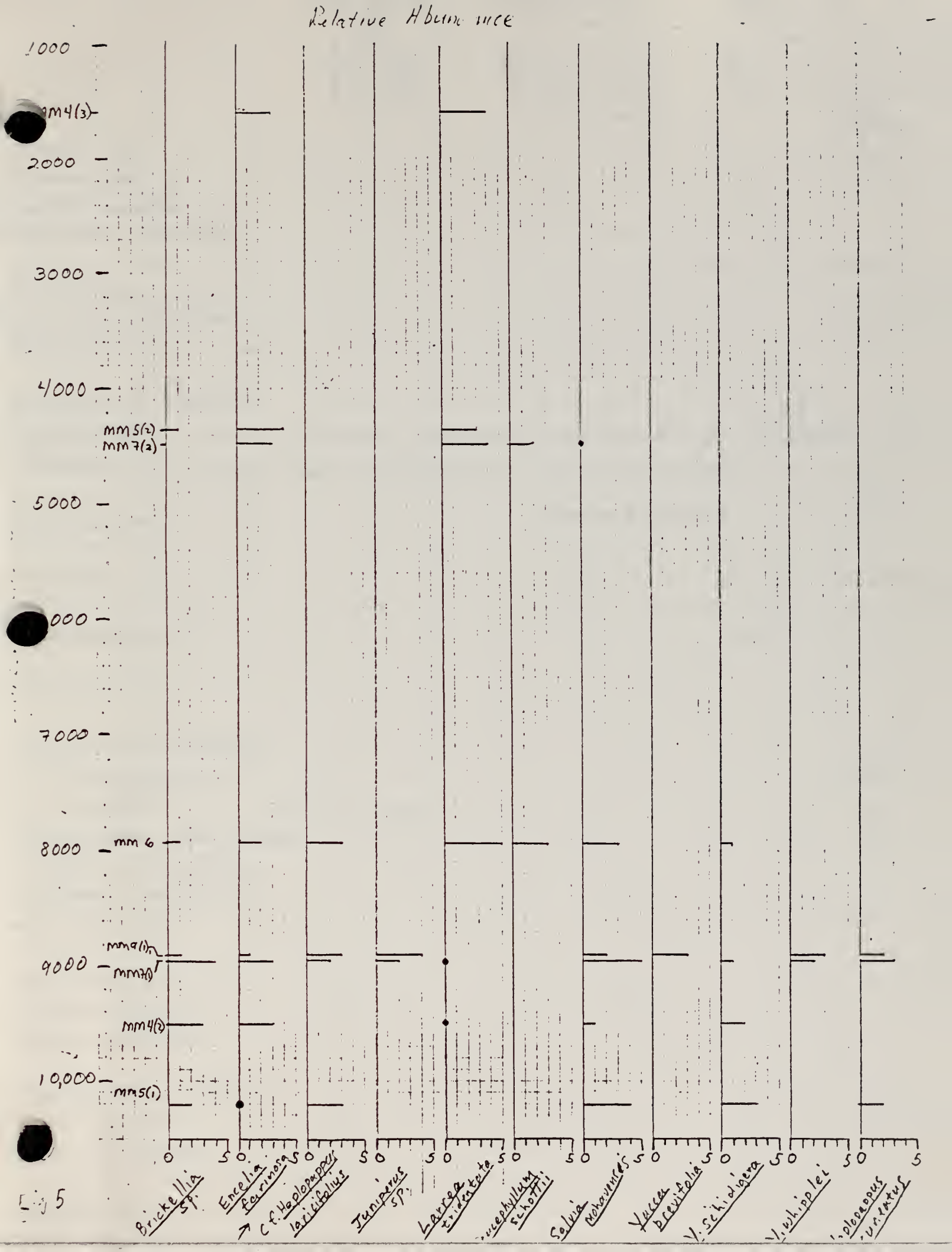

Relative Abundance
1000
2000
3000
4000
5000
7000
8000
9000
10,000
mm4(3)
mm5(2)
mm7(2)
mm 6
mm4(1)
mm7(1)
mm4(2)
mm5(1)
0
5
Brickellia sp.
Encelia farinosa
cf. Haplopappus laricifolius
Juniperus sp.
Larrea tridentata
Eucephyllum schottii
Salvia Mohavensis
Yucca brevifolia
Y. schidigera
Y. whipplei
Idiopappus curvatus

Fig 5

Table 4. Plants from Marble Mountains Locality C. See Table 1 for a key to abbreviations and relative abundance values.

	Marble Mts 6		Marble Mts. 7			Marble Mts. 9			
	Current Vegetation	MM6 7930± 285 GX-6185	Current Vegetation	MM7(1) 8925± 360 GX-6186	MM7(2) 4475± 170 GX-6187	Current Vegetation	MM9(1)$_1$ 8905± 265 GX-6188	MM9(1)$_2$ 10,555± 210 GX-6189 7635± 260 ~~GX-6190~~	MM9(2) 552[illegible] ± 190 GX-6190
Agropyron sp.	–	–	–	–	–	–	1	1	–
Amaranthus sp.	–	–	–	–	–	–	–	1	
Ambrosia dumosa	5	1	2	1	1	3	–	–	–
Amsinckia intermedia	–	–	–	–	1	–	–	–	–
Artesselata	x	1	x	1	–	x	2	1	1
Aristida adscensionis >	x	–	x	–	–	x	–	–	–
Aristida sp.	–	1	–	–	1	–	–	1	1
Artemisia sec. Tridentatae	–	–	–	1	–	–	2	–	1
Asclepias sp.	–	–	–	1	–	–	–	–	–
Astragalus sp.	–	3	–	1	–	–	1	2	1
Bebbia juncea	1	1	1	–	2	1	1	1	2
Brickellia sp.	–	1	–	4	–	–	1	1	–
Calandrinia sp.	–	1	–	–	–	–	–	–	–
		1							
Chaenactis sp.	–	–	–	–	–	–	–	–	1
Chorizanthe brevicornu >	x	–	x	–	–	x	–	–	–
C. cf. brevicornu	–	1	–	2	1	–	–	1	1
C. cf. rigida	–	–	–	–	–	–	1	–	–
cf. Haplopappus laricifolius	TO NEXT PAGE –	3	–	2	–	–	3	3	–
Coleogyne ramosissima	–	–	–	–	–	–	1	2	–
Cryptantha angustifolia >	x	–	x	–	–	x	–	–	–
Cryptantha sp.	–	–	–	–	1	–	2	1	–
Cucurbita sp.	–	–	–	1	–	–	–	–	1
cf Dalea fremontii	–	–	–	1	1	–	–	–	–
Ditaxis lanceolata	1	–	1	–	–	1	–	–	–
Echinocereus engelmannii	1	–	1	–	–	1	–	–	–
Encelia farinosa	2	2	4	3	3	5	1	1	3
Ephedra cf viridis	–	–	–	–	–	–	–	–	1
Ephedra sp.	–	1	–	1	–	–	1	–	–

	Marble Mts 6		Marble Mts 7			Marble Mts 9			
	current vegetation	MM6 7930± 285	current vegetation	MM7(1) 8925± 360	MM7(2) 4475± 170	current vegetation	MM9(1) 8905± 265	MM9(1)$_2$ 10,655± 210 / 7635± 260	MM9(2) 6520± 19
Eriogonum fasciculatum	–	1	–	1	–	–	1	(1)	1
Eschscholtzia sp.	–	2	–	–	–	–	–	–	–
Eucnide urens	–	–	–	–	–	–	–	(1)	–
Ferocactus acanthodes	–	–	–	2	1	–	–	–	–
Festuca sp.	–	–	–	–	–	–	–	–	1
Filago sp.	–	3	–	–	1	–	–	(1)	1
Gutierrezia microcephala	–	–	–	1	–	–	–	–	–
Haplopappus cuneatus	–	–	–	3	–	–	2	(4)	–
Juniperus sp. H. laricifolius	–	–	–	2	–	–	4	(1)	–
Linum sp.	–	–	–	–	–	–	–	–	1
Larrea tridentata	3	5	1	(1)	4	2	–	(1)	2
Lepidium sp.	–	1	–	1	1	–	1	(1)	–
cf. Linanthus sp.	–	–	–	1	–	–	2	–	–
Mentzelia sp.	x	–	x	–	–	x	–	–	–
Mirabilis bigelovii >	1	–	1	–	–	1	–	–	–
Mirabilis sp.	–	1	–	1	1	–	–	–	–
Nicotiana trigonophylla	2	–	1	–	–	1	–	–	–
Opuntia sp. >	–	–	–	–	1	–	–	(1)	1
Opuntia cf. acanthocarpa	–	2	–	–	–	–	2	–	–
O. basilaris	–	–	–	1	–	–	–	(1)	–
cf. Lycium californicum	2	–	2	–	–	0	–	–	–
Pectocarya cf. platycarpa >	–	–	–	–	–	–	–	1	–
P. cf. recurvata >	–	–	–	–	–	–	–	1	1
Pectocarya sp.	–	1	–	1	1	–	–	–	–
Penstemon sp.	–	–	–	1	–	–	1	1	–
Perityle emoryi >	1	–	1	–	–	1	–	–	–
Perityle cf. emoryi	–	–	–	–	1	–	–	–	1
Porcephyllum schottii	1	3	3	–	2	0	–	1	3
Phacelia crenulata >	x	–	x	–	–	x	–	–	–
Phacelia sp.	–	–	–	–	–	–	1	1	–
Physalis crassifolia	–	1	–	1	1	–	(1)	–	1

	Marble Mts 6		Marble Mts 7			Marble Mts. 9			
	Current Vegetation	MM 6 7930± 285	Current Vegetation	MM 7(1) 8925± 360	MM 7(2) 4475± 170	Current Vegetation	MM 9(1)$_1$ 8905± 265	MM 9(1)$_2$ 10,555± 210 / 7635± 260	M. 9(55- 14
Plagiobothrys sp.	–	–	–	1	–	–	–	–	–
Plantago insularis >	x	–	x	–	–	x	–	–	–
Plantago sp.	–	1	–	–	1	–	–	1	–
Pleurocarpus pluriseta	1	1	3	–	–	1	–	1	–
Ribes cf. *montigenum*	–	–	–	–	–	–	1	–	
Salvia sp.	–	1	–	1	–	–	1	1	–
Salvia mohavensis	–	3	–	5	(1)	–	2	5	
cf. *Sarcostemma hirtellum*	–	–	–	–	–	–	1	1	1
Sphaeralcea sp.	–	1	–	1	1	–	1	–	1
Stipa sp.	–	–	–	1	–	–	–	1	–
Thysanocarpus sp.	–	–	–	1	–	–	1	1	1
Yucca brevifolia	–	–	–	–	–	–	3	1	–
Yucca cf. *schidigera*	0	1	0	1	–	0	–	2	
Y. whipplei	–	–	–	2	–	–	3	1	–
N =	19	27	19	33	21	17	29	35	2
N_p =	12	16	12	22	13	10	18	19	1
IS =	–	50.0	–	23.5	56	–	14.3	~	~

The two assemblages also have lower similarity indices with the relevés than either older or younger samples (Fig. 3b). It seems that these two samples may mark a brief period when conditions were effectively more moist in this area.

Early Holocene assemblages from Marble Mountains Locality B and C document the presence of few woodland species besides Juniperus sp. Prunus fasciculata, Artemisia sec. Tridentatae, Cowainia mexicana, and Ribes cf. montigenum do occur in small amounts, but only gooseberry is restricted to woodland and montane habitats today.

Van Devender's model of the development of modern desert vegetation and climate in western North America calls for an increase in average annual temperatures starting by ca. 11,000 years B.P. but the persistence of the Pleistocene precipitation regime for another 3000 years (Van Devender 1977; Van Devender and Spaulding 1979). The fossil plant data from the Marble Mountains are consistent withthis hypothesis. In the 2300 year interval between ca. 10,200 B.P. and ca. 7900 B.P. the present warm desert dominants became establised. But many extralocal shrubs persisted. The final demise of the more mesophytic plant species at Localities B and C lagged behind the invasion of creosote bush, brittle bush, and desert spruce (Fig. 5). While the expansion of xerophytes was due to increasing temperatures, the extirpation of many mesophytes may have been due to the final failure of the Wisconsinan rainfall regime, shortly after 8000 B.P.

Prunus fasciculata and Cowania mexicana occur only in the oldest assemblage, MM 5(1) at 10,210 ± 260 B.P. (average of GX-6182 and GX-6183). Other extralocal shrubs appear to persist at these sites until sometime after ca. 8900 B.P. MM $9(1)_1$ (at 8905 ± 265 B.P., GX-6188) is the youngest midden sample to contain Haplopappus cuneatus and Coleogyne ramosissima and the only one to contain Yucca brevifolia (Table 4). The thousand year hiatus in the record, between ca. 8900 B.P. and ca. 7900 B.P., saw the elimination of these plants at Locality C. Salvia mohavensis, cf. Haplopappus laricifolius, Brickellia sp., and Yucca schidigera still occur in MM 6 (7930 ± 285 B.P., GX-6185; Fig. 5).

Encelia farinosa is the first of the present dominants to become important in the midden record. It is common in MM 4(2) at 9515 ± 185 B.P. (GX-6180). Larrea tridentata and Peucephyllum schottii do not appear in appreciable quantities until the MM 6 assemblage at ca. 7900 B.P. (Fig. 5).

The early Holocene fossil record from the Marble Mts. is dry in contrast to contemporaneous assemblages further east in the Lower Colorado Valley section of the Sonoran Desert. Apart from the infrequency of juniper, the lack of Acacia greggii is notable. Catclaw acacia, common along washes today, occupied drier hillslope sites during the early Holocene in the Whipple Mountains of California (Van Devender 1977) as well as the Artillery Mountains and New Water Mountains of adjacent Mohave and Yuma Counties, Arizona

(Van Devender 1973). Catclaw occurs in washes near Localities B and C in the Marble Mountains but a single spine in MM 4(2) is its only fossil record (Table 4).

Yucca schidigera is also restricted to washes in the Brown Buttes area. Rare individuals can be seen within half a kilometer of the sites. But, in contrast to Acacia greggii, its remains are common in early Holocene middens from both localities, (Table 3, 4).

Two contemporaneous assemblages, MM 7(2) and MM 5(2) at 4475 ± 170 B.P. (GX-6187) and 4360 ± 210 B.P. (GX-6184), respectively, show little difference from the present plant communities. The presence of Ferocactus acanthodes and Opuntia sp. in MM 7(2) and Cucurbita sp. in MM 5(2) is provocative in the light of Martin's (1963) hypothesis concerning an increase in monsoonal activity to the east during the mid-Holocene, but inconclusive.

Marble Mts. 4(3), the youngest assemblage at 1680 ± 150 B.P. (GX-6181), has an unexpectedly low IS coefficient for a late Holocene assemblage (Fig. 3b). Ambrosia dumosa and Ferocactus acanthodes, present in middle Holocene samples, are missing from this assemblage (Table 3). Persuasive evidence for a cool late Holocene climatic episode, roughly corresponding to Antevs' (1955) Medithermal, was provided by LaMarche (1973). The upper elevational limit of treeline in the White Mountains, ca. 400 km. (240 mi.) to the northwest, dropped ca. 3700 years ago. The packrat midden record

from the Sheep Range in the Mojave Desert of Nevada, ca. 210 km. (130 mi.) to the north-northeast contains evidence for a lowering of the woodland-desert boundary and subalpine forest at this time (Spaulding 1977, unpub.). Perhaps it was too cool to support white bursage and barrel cactus at Marble Mountains Locality B ca. 1700 years ago.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-6177 — **Date Received:** 18 December 1978

Your Reference: letter of 13 December 1978 — **Date Reported:** 10August 1979

Submitted by: W. G. Spaulding
Department of Geosciences
The University of Arizona
Tucson, ARIZONA 85721

Contract #CA-060-PH8-000725

Sample Name: Sample #1. Marble Mountains 1. Midden.

AGE = 3080 ± 165 C-14 years B.P.

Description: Sample of Neotoma feces from packrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment: This sample was relatively small, yielding only 420 mg. of carbon instead of the ideal 1.0 grams. It was counted on each of two days with concordant results.

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-6178 **Date Received:** 12 December 1978

Your Reference: letter of 13 December 1978 **Date Reported:** 31 August 1979

Submitted by: W. G. Spaulding
Department of Geosciences
The University of Arizona
Tucson, ARIZONA 85721

CAntract #CA-060-PH8-000725

Sample Name: Sample #2. Marble Mountains 2. Midden.

AGE = 10,465 ± 330 C-14 years B.P.

Description: Sample of Neotoma feces from packrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment:

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-6179 — **Date Received:** 18 December 1978

Your Reference: letter of 13 December 1978 — **Date Reported:** 31 August 1979

Submitted by: W. G. Spaulding
Department of Geosciences
The University of Arizona
Tucson, ARIZONA 85721

Contract #CA-060-PH8-000725

Sample Name: Sample #3. Marble Mountains 3. Midden.

AGE = 1465 ± 180 C-14 years B.P.

Description: Sample of Larrea tridentata twigs and leaves from packrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment: This sample was relatively small, yielding only 180 mg. of carbon instead of the ideal 1.0 grams. It was counted on each of two days with concordant results.

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-6180 **Date Received:** 18 December 1978

Your Reference: letter of 13 December 1978 **Date Reported:** 31 August 1979

Submitted by: W. G. Spaulding
Department of Geosciences
The University of Arizona
Tucson, ARIZONA 85721

Contract #CA-060-PHS-000725

Sample Name: Sample #4. Marble Mountains 4 (2). Midden.

AGE = 9515 ± 185 C-14 years B.P.

Description: Sample of Neotoma feces from packrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment:

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-6181 **Date Received:** 18 December 1978

Your Reference: letter of 13 December 1978 **Date Reported:** 31 August 1979

Submitted by: W. G. Spaulding
Department of Geosciences
The University of Arizona
Tucson, ARIZONA 85721

Contract #CA-060-PH8-000725

Sample Name: Sample #5. Marble Mountains 4 (3). Midden.

AGE = 1680 ± 150 C-14 years B.P.

Description: Sample of twigs from packrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment:

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-6182 — **Date Received:** 18 December 1978

Your Reference: letter of 13 December 1978 — **Date Reported:** 31 August 1979

Submitted by: W. G. Spaulding
Department of Geosciences
The University of Arizona
Tucson, ARIZONA 85721

Contract #CA-060-PH8-000725

Sample Name: Sample #6. Marble Mountains 5 $(1)_3$. Midden.

AGE = 10,090 ± 380 C-14 years B.P.

Description: Sample of twigs and Prunus fasciculata seeds from packrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment:

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-6183

Date Received: 18 December 1978

Your Reference: letter of 13 December 1978

Date Reported: 31 August 1979

Submitted by: W. G. Spaulding
Department of Geosciences
The University of Arizona
Tucson, ARIZONA 85721

Contract #CA-060-PH8-000725

Sample Name: Sample #7. Marble Mountains 5 $(1)_3$. Midden.

AGE = 10,325 ± 350 C-14 years B.P.

Description: Sample of Neotoma feces from packrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment:

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-6184

Date Received: 18 December 1978

Your Reference: letter of 13 December 1978

Date Reported: 31 August 1979

Submitted by: W. G. Spaulding
Department of Geosciences
The University of Arizona
Tucson, ARIZONA 85721

Contract #CA-060-PH8-000725

Sample Name: Sample #8. Marble Mountains 5 (2). Midden.

AGE = 4360 ± 210 C-14 years B.P.

Description: Sample of twigs fromppackrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment: This sample was relatively small, yielding only 425 mg. of carbon instead of the ideal 1.0 grams. It was counted on each of two days with concordant results.

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-6185 — **Date Received:** 18 December 1978

Your Reference: letter of 13 December 1978 — **Date Reported:** 31 August 1979

Submitted by: W. G. Spaulding
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Contract #CA-060-PH8-000725

Sample Name: Sample #9. Marble Mountains 6. Midden.

AGE = 7930 ± 285 C-14 years B.P.

Description: Sample of twigs from packrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment:

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-6186

Date Received: 18 December 1978

Your Reference: letter of 13 December 1978

Date Reported: 31 August 1979

Submitted by: W. G. Spaulding
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Contract #CA-060-PH8-000725

Sample Name: Sample #10. Marble Mountains 7 (1). Midden.

AGE = 8925 ± 360 C-14 years B.P.

Description: Sample of twigs from packrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment: This sample was relatively small, yielding only 230 mg. of carbon instead of the ideal 1.0 grams. It was counted on each of two days with concordant results.

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-6187 — **Date Received:** 18 December 1978

Your Reference: letter of 13 December 1978 — **Date Reported:** 31 August 1979

Submitted by: W. G. Spaulding
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Tucson, ARIZONA 85721

Contract #CA-060-PH8-000725

Sample Name: Sample #11. Marble Mountains 7 $(2)_2$. Midden.

AGE = 4475 ± 170 C-14 years B.P.

Description: Sample of Neotoma feces from packrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment:

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-6188

Your Reference: letter of 13 December 1978

Submitted by: W. G. Spaulding
Department of Geosciences
The University of Arizona
Tucson, ARIZONA 85721

Date Received: 18 December 1978

Date Reported: 31 August 1979

Contract #CA-060-PH8-000725

Sample Name: Sample #12. Marble Mountains 9 $(1)_1$. Midden.

AGE = 8905 ± 265 C-14 years B.P.

Description: Sample of Juniperus sp. twigs and seeds from packrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment:

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-6189 — **Date Received:** 18 December 1978

Your Reference: letter of 13 December 1978 — **Date Reported:** 31 August 1979

Submitted by: W. G. Spaulding
Department of Geosciences
The University of Arizona
Tucson, ARIZONA 85721

Contract #CA-060-PH8-000725

Sample Name: Sample #13. Marble Mountains 9 $(1)_2$. Midden.

AGE = 10,555 ± 210 C-14 years B.P.

Description: Sample of twigs from packrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment:

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-6190

Date Received: 18 December 1978

Your Reference: letter of 13 December 1978

Date Reported: 31 August 1979

Submitted by: W. G. Spaulding
Department of Geosciences
The University of Arizona
Tucson, ARIZONA 85721

Contract #CA-060-PH8-000725

Sample Name: Sample #14. Marble Mountains 9 $(1)_2$. Midden.

AGE = 7635 ± 260 C-14 years B.P.

Description: Sample of *Neotoma* feces from packrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment: This sample was relatively small, yielding only 230 mg. of carbon instead of the ideal 1.0 grams. It was counted on each of two days with concordant results.

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-6191

Your Reference: letter of 13 December 1978

Submitted by: M. G. Spaulding
Department of Geosciences
The University of Arizona
Tucson, ARIZONA 85721

Date Received: 18 December 1978

Date Reported: 31 August 1979

Contract #CA-060-PH8-000725

Sample Name: Sample #15. Marble Mountains 9 (2). Midden.

AGE = 5520 ± 190 C-14 years B.P.

Description: Sample of Neotoma feces from packrat midden.

Pretreatment: The sample was treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids or other alkali soluble compounds. It was then washed and dried prior to combustion to recover carbon dioxide for the analysis.

Comment:

δC^{13}_{PDB} = ‰.

Notes: This date is based upon the Libby half life (5570 years) for C^{14}. The error stated is ±1 σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.